REMARKS

Claims 1-10 were examined and reported in the Office Action. Claims 1-10 are rejected. Claims 1-10 remain. Applicant submits response Figures 1-7 to assist in understanding Applicant's assertions that distinguish the cited prior art references. No new matter is submitted or used to assert distinguishing limitations.

Applicant requests reconsideration of the application in view of the following remarks.

I. 35 U.S.C. § 103(a)

A. It is asserted in the Office Action that claims 8-10 are rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,294,568 issued to McNeilly et al. ("McNeilly") in view of U.S. Patent No. 5,772,902 issued to Reed et al. ("Reed"). Applicant respectfully disagrees.

Applicant's claim 8 contains the limitations of "A method for removing silicon oxide of a sacrificial layer for a microstructure in a MEMS device, characterized by removing the silicon oxide of a sacrificial layer with a vapor etching using anhydrous HF and alcohol by controlling a temperature and a pressure inside of an etching chamber to be within the region of a vapor of a phase equilibrium diagram of water." Therefore, Applicant's claimed invention relates to a stiction-free microstructure releasing method for fabricating a MEMS element. In other words, Applicant's claimed invention regards fabricating a MEMS element by etching the silicon oxide of the sacrificial layer and separating the microstructure from the substrate without any adhesion/stiction.

It should be noted that in prior art technology, in order to fabricate a MEMS element that includes microstructure, a sacrificial layer such as a silicon oxide is deposited on a silicon substrate or a silicon/insulating layer substrate (see, submitted response Figure 1 (a)). After depositing microstructure, e.g., polysilicon, on a sacrificial layer, a MEMS element such as a sensor or an actuator is fabricated by etching the sacrificial layer and

releasing the microstructure (see, submitted response Figure 1 (b)). In the conventional fabrication method, however, a problem arises due to leaving the cleansing solution in a gap of a micron unit between the microstructure and the substrate in the drying process used for evaporating the cleansing solution. A capillary force is generated by a surface tension due to the residue. If the capillary force becomes greater than the retrieving force, the microstructure tentatively sticks on the substrate. Such a tentative sticking is changed into a permanent surface sticking due to the van der Waals force, electrostatic force or hydrogen bridging. This phenomenon is referred to as adhesion, stiction, sticking, peeling or friction phenomenon. (see, submitted response Figure 1(e)]; Roya Maboudian and Roger T. Howe, *Critical Review: Adhesion in surface micromechanical Structures*, J. Vac. Sci. Technol. B 15(1), Jan/Feb 1997, pp.1-20).

To avoid stiction and residue, research has been conducted in diverse aspects. Methods presented at the initial stage of the research consisted of reducing the contacting surface of the silicon by roughing and widening the surface area thereof, or undergoing an NH_4F process for the silicon so as to be hydrophobic. These methods, however, failed to release the microstructure on a revivable basis. Other suggested methods consist of a supercritical CO_2 drying method (see, Gregory T. Mulhem et al., *Supercritical Carbon Dioxide Drying of Microstructures*, The 7-th Int. Conf. on Solid-State Sensors and Actuators, 1993, pp. 296-299) using the characteristics of a phase transfer to a supercritical fluid by lowering the pressure after moving the cleansing solution to a supercritical region and converting the cleansing solution to a fluid, which is an intermediate state between gas and liquid, and a sublimation method of directly solidifying the cleansing solution by using sublime materials such as t-butyl alcohol, p-DCB (dicholorobenzene), etc. without undergoing a liquid state (see, Dai Kobayashi, Toshiki Hirano, Tomodake Furuhata, Hiroyuki Fujita, *An Integrated Lateral Tunneling Unit*, Proc. IEEE Micro Electro Mechanical System, 1992, pp. 214-219.). These methods, however, also have associated problems in that they fail to completely remove the water, fail to release the silicon microstructure on a revivable basis, or are consist of a complicated process while being very difficult in handling test pieces.

McNeilly discloses a method for selective etching of native oxide on a substrate where hydrogen halide vapor and water vapor are exposed to the substrate surface under appropriate conditions and for a long enough time in order to remove native oxide, but not long enough to remove any significant amount of other oxides.

The object of the Applicant's invention, however, is not etching the silicon oxide as disclosed by McNeilly, but fabricating an MEMS element by etching the silicon oxide of the sacrificial layer and separating the microstructure from the substrate without any adhesion/stiction. (See, Applicant's submitted response Figure 1(f)). Regarding Applicant's invention, de-ionized (DI) water, methanol, isopropyl alcohol or 2-Propanol, which is used in the chemical reaction, is used as only a catalyst. The HF gas reacts with the alcohol such as methanol, isopropyl alcohol or 2-Propanol and water (H_2O) must be generated. In order to vaporize the by-products of H_2O, SiF_4 and CH_3Oh without condensation on the microstructure after being released, the process pressure and temperature are controlled.

McNeilly discloses that introducing fewer impurity controls, etch uniformity and wet etching and condensation are delayed by the process pressure and temperature. McNeilly, however, fails to teach, disclose or suggest that H_2O or CH_3OH on the silicon oxide surface ionizes the absorbed HF by using the catalyst, e.g., the alcoholic vapor, generates more etching factor HF_2^-, and the silicon oxide reacts with the HF_2^- vaporizes the water completely without being condensed on the substrate in the gas line or the etch chamber.

Further, referring to Figure 3 of McNeilly, the vapor pressure of H_2O in the etch chamber is 10-30 Torr. In Applicant's invention, the process pressure during etching is 25-75 Torr, and referring to Applicant's submitted response Figure 7, the vapor pressure of H_2O is 25-350 Torr at 25-80°C, and 30 Torr at 35°C. Therefore, in Applicant's invention, if the process pressure is 25-75 Torr, the process temperature is 35-80°C, the gas-phase regime is maintained and etching is performed.

Reed discloses a method for inhibiting stiction of suspended microstructures during post-release-etch rinsing and drying where a wet etching is used. In a conventional etching process of silicon oxide, such as disclosed by Reed, the silicon oxide is used as the sacrificial layer and polysilicon is used as the microstructure, and a HF solution is generally used for wet etching to remove the silicon oxide. A cleansing solution such as a DI water, methanol, isopropyl alcohol or 2-Propanol is used to rinse and remove the remaining HF solution. (See, Applicant's submitted response Figure 1(c).

Applicant's claimed invention, however, discloses a dry etching process where the etching mechanism is entirely distinguishable from that disclosed by Reed. Referring to Applicant's submitted response Figure 2, the silicon oxide of the sacrificial layer is removed in etch profile t_1-t_5 from the etch front (t_0) where the microstructure is defined. A SEM photograph of etch profiles is illustrated in Applicant's submitted response Figure 3.

While McNeilly teaches a method for etching of the silicon oxide and the sacrificial layer, illustrated in Applicant's submitted response Figure 1(a), and Reed teaches a wet HF etching of the silicon oxide and microstructure, such as various type of cantilever or clamped beams, which is illustrated in Applicant's submitted response Figures 1(b)-1(d) and 1(f), neither reference discloses, teaches or suggests the limitations contained in Applicant's claim 8, as listed above. Since neither McNeilly, Reed, nor the combination teach, disclose or suggest the limitations contained in Applicant's claim 8, there would be no motivation to arrive at Applicant's claimed invention by combining the references since the resulting invention of such combination would still not contain Applicant's claimed limitations, as listed above. Therefore, Applicant's claim 8 is patentable over McNeilly in view of Reed. Additionally, the claims that directly or indirectly depend from Applicant's claim 8, namely claims 9-10, are also patentable over McNeilly in view of Reed for the same reason.

B. It is asserted in the Office Action that claims 1-3, 5-7 are rejected under 35 U.S.C. § 103(a) as being unpatentable over McNeilly in view of U.S. Patent No. 6,126,734 issued to Bergman et al. ("Bergman") and further in view of Reed. Applicant respectfully disagrees.

Applicant's claim 1 contains the limitations of "A method for releasing a microstructure for fabricating a device of a micro electro mechanical system (MEMS), comprising the steps of: supplying alcohol vapor bubbled with anhydrous HF; maintaining a temperature of the supplying device and a moving path of the anhydrous HF and the alcohol to be higher than a boiling point of the alcohol; performing a vapor etching by controlling a temperature and a pressure to be within the vapor region of a phase equilibrium diagram of water; and removing silicon oxide of a sacrificial layer on a lower portion of the microstructure." In other words, Applicant's claimed invention regards fabricating a MEMS element by etching the silicon oxide of the sacrificial layer and separating the microstructure from the substrate without any adhesion/stiction.

As discussed above in section I(A), neither reference discloses, teaches or suggests the limitations contained in Applicant's claim 8. The same arguments and assertions regarding McNeilly and Reed also apply to Applicant's claim 1, and are thus incorporated in this section in reference to claim 1.

Bergman discloses a vapor generator. In Applicant's claimed invention, however, by maintaining the gas line at 100°C, alcohol vapor is prevented from being condensed in a gas tube and not being applied, nitrogen which is used as a carrier gas, is used for controlling the vapor pressures of HF and alcohol vapor inside the etching chamber.

Since neither McNeilly, Bergman, Reed, nor the combination teach, disclose or suggest the limitations contained in Applicant's claim 1, there would be no motivation to arrive at Applicant's claimed invention by combining the references since the resulting invention of such combination would still not contain Applicant's claimed limitations, as listed above. Therefore, Applicant's claim 1 is patentable over McNeilly in view of Bergman and in further view of Reed. Additionally, the claims that directly or indirectly depend from Applicant's claim 1, namely claims 2-3 and 5-7, are also patentable over McNeilly in view of Bergman and in further view of Reed for the same reason.

C. It is asserted in the Office Action that claim 4 is rejected under 35 U.S.C. § 103(a) as being unpatentable over McNeilly in view of Bergman and further in view of Reed, and U.S. Patent No. 6,126,847 issued to Thakur et al. ("Thakur"). Applicant respectfully disagrees.

As discussed above in sections I(A) and (B), none of the references disclose, teach or suggest the limitations contained in Applicant's claim 1. Since Applicant's claim 4 directly depends from Applicant's claim 1, and Applicant's claim 1 has similar limitations to Applicant's claim 8, the same arguments and assertions regarding McNeilly, Reed and Bergman also apply to Applicant's claim 4, and are thus incorporated in this section in reference to claim 4.

Thakur discloses a wet etching method for high selectivity of silicon oxide by maintaining the temperature of a container including halide species in the range from room temperature to 100°C, which is distinguishable from the present invention (see Applicant's assertions in Section I(A)). Similarly to McNeilly, Reed and Bergman, Thakur does not teach, disclose or suggest the limitations contained in Applicant's claim 1.

Since neither McNeilly, Bergman, Reed, Thakur, nor the combination teach, disclose or suggest the limitations contained in Applicant's claim 1, there would be no motivation to arrive at Applicant's claimed invention by combining the references since the resulting invention of such combination would still not contain Applicant's claimed limitations, as listed above. Therefore, Applicant's claim 1 is patentable over McNeilly in view of Bergman and in further view of Reed and Thakur. Additionally, the claims that directly or indirectly depend from Applicant's claim 1, namely claim 4, is also patentable over McNeilly in view of Bergman and in further view of Reed and Thakur for the same reason.

Accordingly, withdrawal of the 35 U.S.C. § 103(a) rejection for claims 1-10 is respectfully requested.

CONCLUSION

In view of the foregoing, it is believed that all claims now pending, namely 1-10, patentably define the subject invention over the prior art of record and are in condition for allowance and such action is earnestly solicited at the earliest possible date.

If necessary, the Commissioner is hereby authorized in this, concurrent and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2666 for any additional fees required under 37 C.F.R. §§ 1.16 or 1.17, particularly extension of time fees.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR, & ZAFMAN

Dated: November 12, 2002

By: _____
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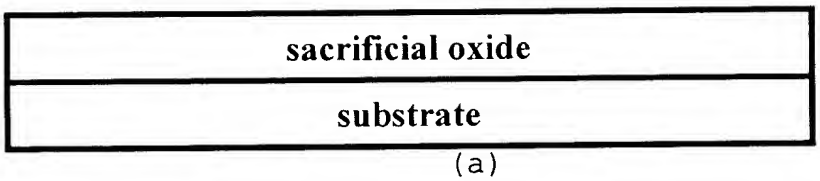
CERTIFICATE OF MAILING:
I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail, with sufficient postage, in an envelope addressed to: Box NON-FEE, Amendments, Commissioner for Patents, Washington, D.C. 20231 on November 12, 2002.

_____
Linda D'Elia November 12, 2002

SL/lmd

Attachments: Figures



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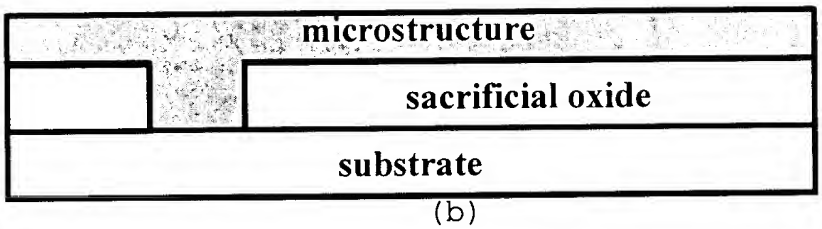

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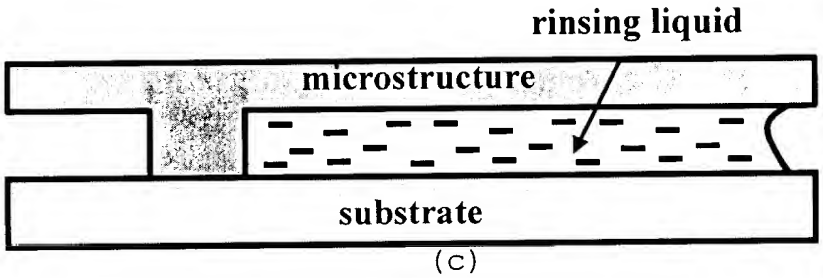

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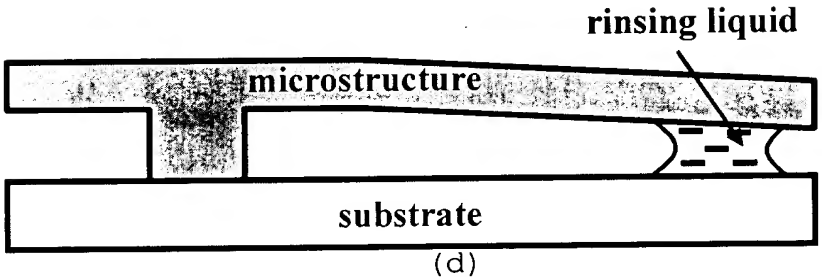

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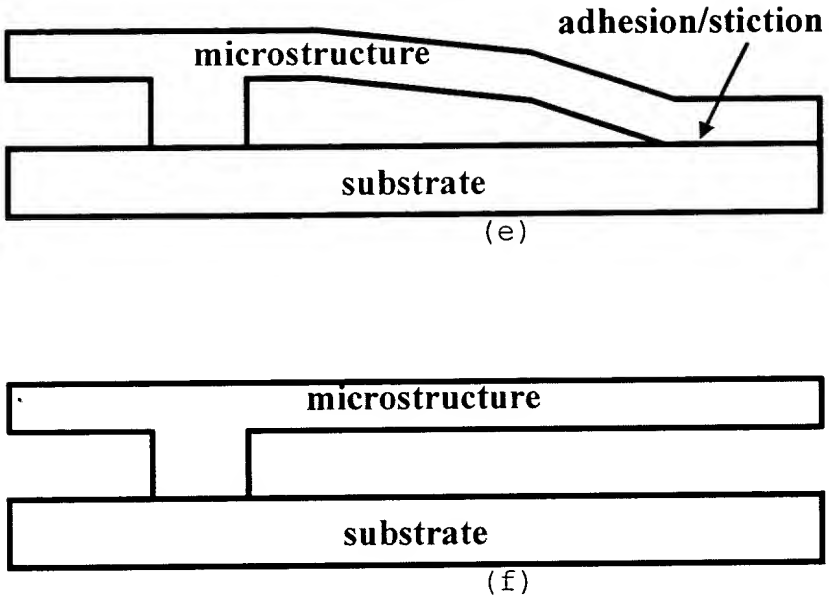


Figure 1 Schematic of cross-sectional view for conventional wet etch process.

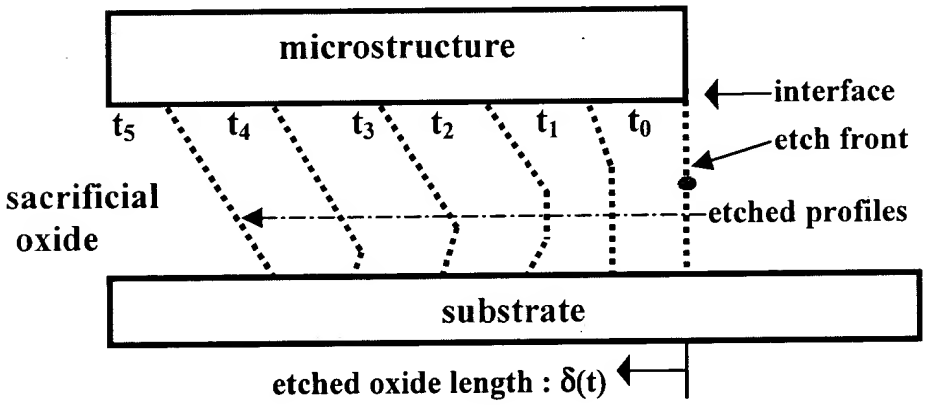


Figure 2 Schematic of etched profiles as a function of etching time to release microstructure.

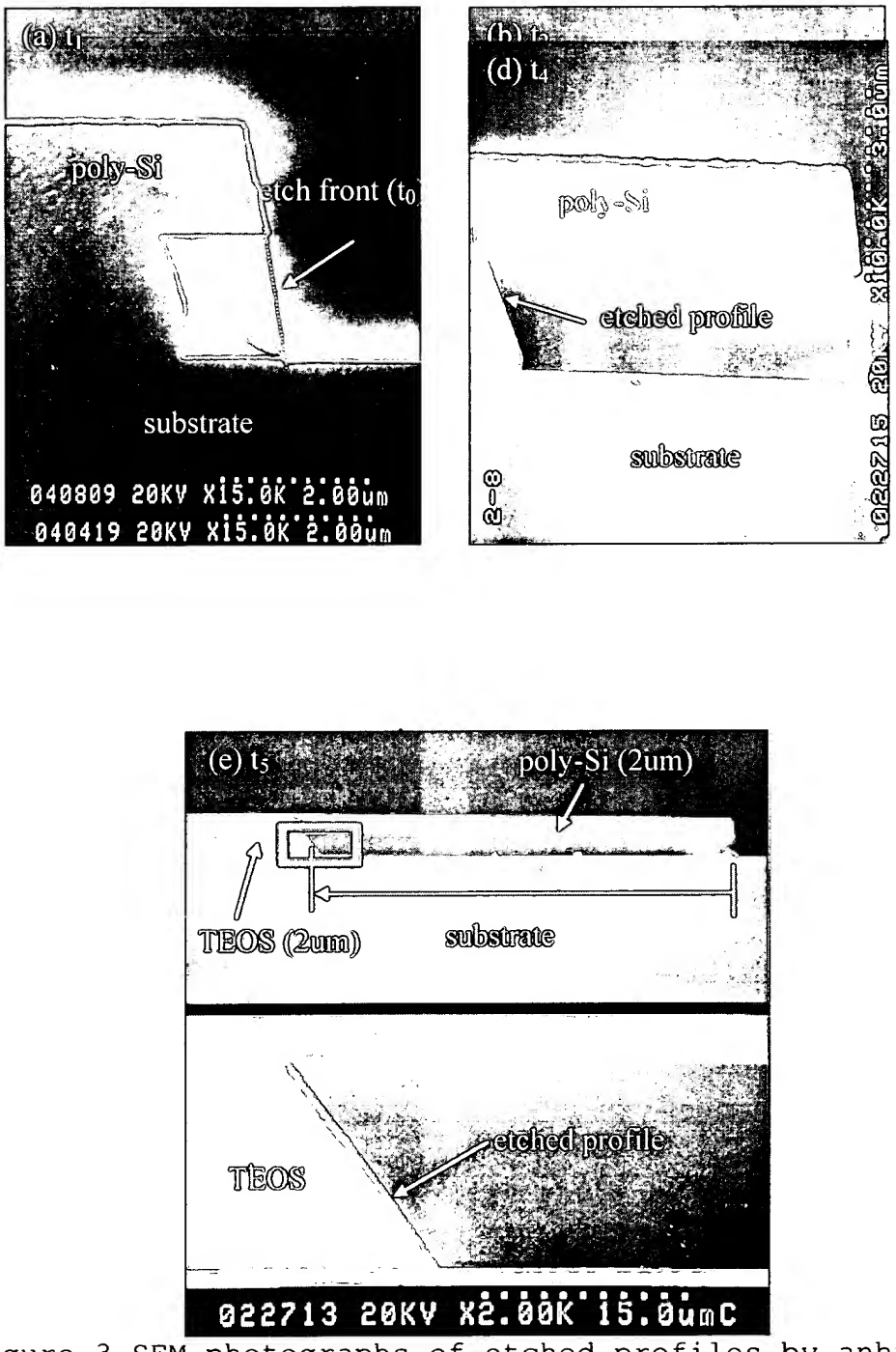


Figure 3 SEM photographs of etched profiles by anhydrous HF gas-phase etching process.

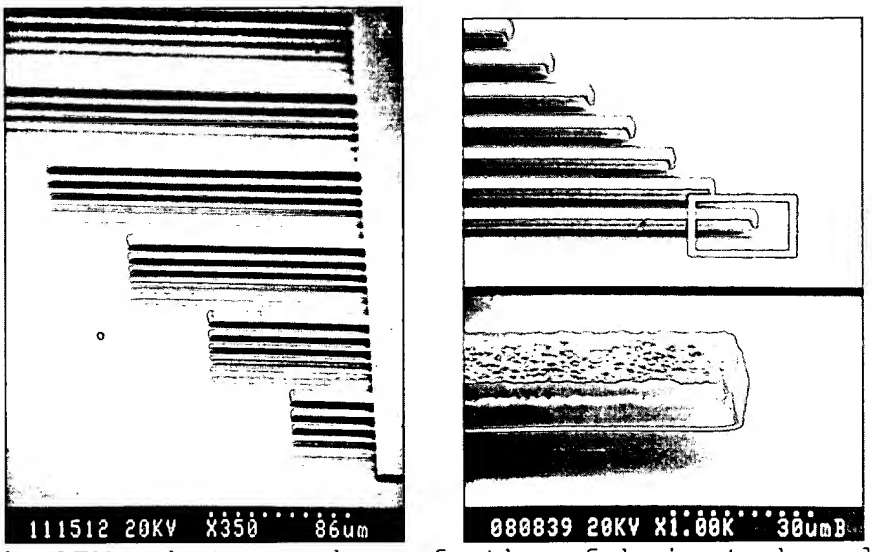
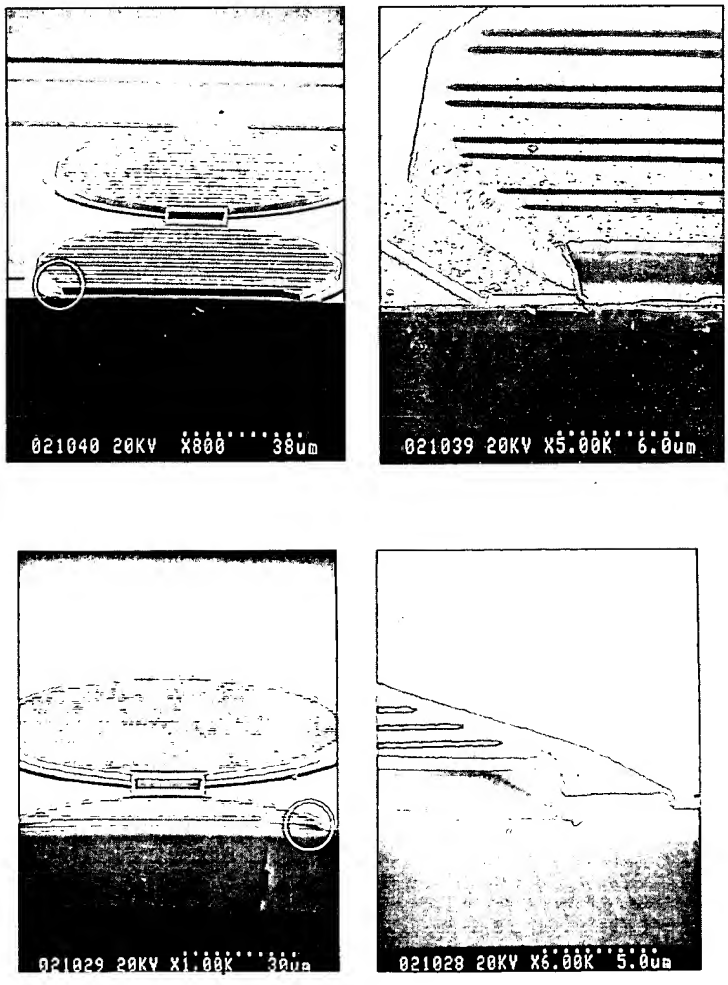


Figure 4 SEM photographs of the fabricated polysilicon cantilevers with no stiction. (thickness 2μm, width 10μm, maximum length 1000 μm, gap between polysilicon and substrate 2μm)



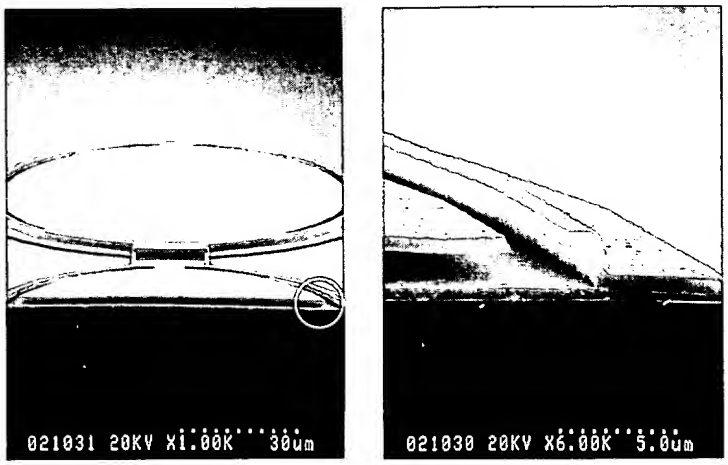


Figure 5 SEM photographs of the fabricated bridge and fan type cantilevers with no stiction. (thickness 0.7μm, maximum diameter 100μm, gap between polysilicon and substrate 1.5μm)

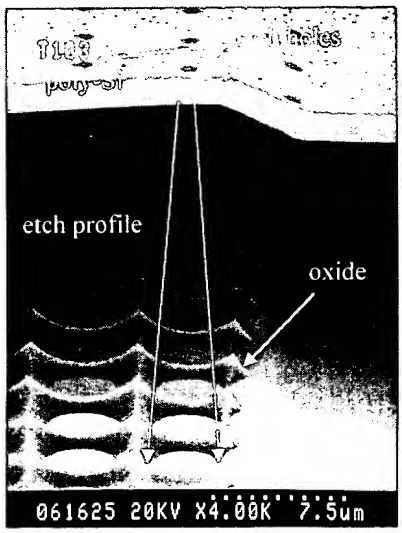


Figure 6 Cross-sectional view of the fabricated membrane after anhydrous HF gas-phase etching process.
(membrane thickness 1.7μm, membrane diameter 1200μm, gap between membrane and substrate 4μm)

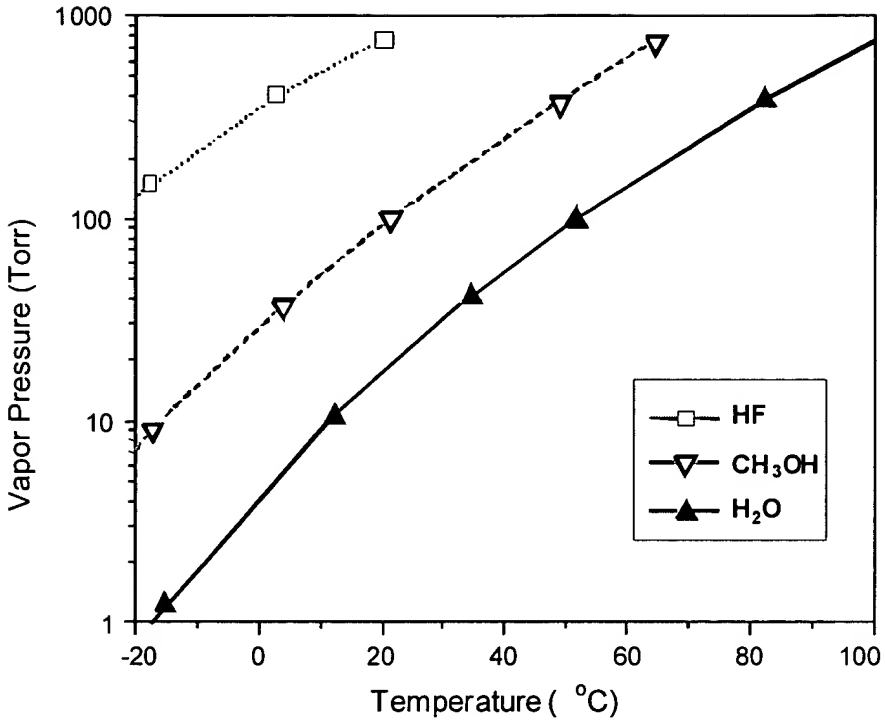


Figure 7 Vapor pressure profiles of HF, methanol, and water as a function of temperature